ESTIMATING THE APEX DEVELOPMENT STAGE OF WINTER WHEAT FROM LEAF NUMBER

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AGRICULTURAL MEMORANDUM 1065

Summary

Research has shown that the apex stages of double ridges and terminal spikelet in wheat are closely related to the number of leaves which have grown up to the stage. These relations are used to estimate the dates of double ridges and terminal spikelet for wheat grown at nine sites in UK, and these dates are compared with observations.

Introduction

In advisory work it is sometimes useful to be able to estimate wheat development stages by a model which takes into account sowing date and altitude of the site. It has been established (Kirby et al, 1982; Kirby et al, 1985) that cereal leaf appearance is closely related to temperature (Ag memo 1002) and also that the development of the plant's growth point, or apex, is related to the leaf number. In particular Kirby et al (1985) give equations which relate the leaf number at the double ridge and terminal spikelet development stages to the total number of leaves which are produced.

Double Ridges

$$d = 0.765 - 1.35\,N \qquad (r^2 > 0.9) \quad \ldots 1.$$

Terminal Spikelet

$$d = 0.765 + 0.634\,N \qquad (r^2 > 0.9) \quad \ldots 2.$$

where d = leaf number at a stage

N = maximum main shoot leaf number.

The rest of this memorandum presents a test of these equations using data from the AFRC Avalon Development Survey.

Avalon Development Survey

In this experiment Avalon winter wheat was sown at sites in England and Scotland to give a wide range of latitudes/climates (Porter & Kirby (1985)). There were three sowing dates: 1. Mid September; 2. Mid October; and 3. Mid November. All crops were sown by hand in the same size of plot and sampling was done in a systematic way. The dates of double ridge and terminal spikelet were noted for each sowing together with the maximum leaf number and air temperature from sowing to harvest. The sites are given in table 1, together with the observed final leaf numbers and rates of leaf appearance in thermal time.

The Calculation of Apex Stages

The dates of double ridges and terminal spikelet were calculated as follows:-

1. The observed maximum leaf number N (table 1) was used in eqns 1 and 2 to find d.

2. The value of d was corrected to allow for the fact that Kirby et al (1985) used emerged leaves (an integer) to derive equations 1 and 2, which on average is about 0.5 of a leaf greater than the 'exact' leaf number. The equation to convert d to 'exact' leaves (x) is:

$$x = 1.01885\, d - 0.7406 \quad \ldots\ldots 3.$$

3. x multiplied by the thermal time per leaf gives the thermal time from emergence to an apex stage, and this value added to 120°C days gives the thermal time from sowing.

4. Records of maximum and minimum air temperature from the three sowing dates were then used with the value of thermal time found in 3. above to give a date. Most sites had published data from a nearby climatological station, though Cambridge NIAB was used for PBI and Starcross was used for Seale Hayne. The data used were the weekly values given in the "Agricultural Meteorological Scheme".

Results

Table 2 gives the observed and calculated dates for the sites, and table 3 gives the mean errors (neglecting the sign of the error). Most sites had at least one or two reasonable 'predictions' of dates, but with some notable anomalies (eg Sutton Bonington sowing 1 DR calculated to be 56 days after the observed date, Brooms Barn sowing 2 calculated to be 25 and 22 days late at DR and TS respectively). Seale Hayne was by far the worst site with the calculated dates ranging from 36 days late (sowing 1 DR) to 36 days early (sowing 3 DR).

Table 3 shows that the mean error was greatest for DR, sowing 1 and became less with the later sowings and for the later development stage (TS). Over all sites and sowings, and taking regard of the sign of the error, the mean error at double ridges was 2.2 days late and at terminal spikelet was 1.5 days early.

Discussion

The pattern of errors in table 3 might be taken as showing that 'predictions' of DR for September sowings are worse than those at TS for November sowings. This is not necessarily so because of two reasons, namely the error in the observed and calculated dates (O and C in table 2) and the different rates of development (ie slow to fast) from sowings 1 to 3.

The observed dates of DR and TS will have an error because samples were not taken every day and because with the DR stage especially it is difficult to give a precise date because the DR stage can last for several weeks especially when development is slow in mid winter. Likewise, small errors in estimating thermal time (eg incorrect thermometers, or small local site effects) can cause errors of several days during cold weather when thermal time is increasing very slowly.

When plant development is rapid it is usually easier to be more precise in giving dates to the stages. In addition, thermal time is accumulating rapidly, so that errors measured in days will also be reduced.

One feature of table 2 is the steady progression of the observed dates. Sowing 2 stages were always later than for sowing 1 and sowing 3 stages were always later than sowing 2. For a few sites the calculated dates did not always show this feature (Sutton Bonington TS dates for sowings 1 and 2, Brooms Barn DR and TS dates for sowings 2 and 3, Seale Hayne DR and TS dates for sowings 1 and 2). The reason for this is not clear, except that the plants used for apex stage assessment were a few m away from the plants used for leaf counts.

Although the method suggested here is not the best which can be used to estimate development stages for wheat (Weir et al (1984) described a direct way to estimate development), it has some advantages for farm use. It can be applied to different varieties of wheat, by allowing for differences in thermal time at DR and TS as found by Haggar (personal communication). Also it is at present the only method for barley since nothing comparable to Weir et al (1984) has been published for barley.

In order to use this technique operationally it is necessary to determine for any sowing date, the maximum leaf number (N) and the rate of leaf appearance in thermal time. N can be related to temperature conditions after sowing (a representation of vernalisation) and the leaf rate (thermal time per leaf) can be estimated from the rate of change of day length after seedling emergence (Baker et al (1980), J Porter (personal communication)). It is hoped to produce the results of such a model in a later memorandum.

Meteorological Office
Harrogate
November 1985

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TABLE 1.

SITES USED IN THE AVALON SURVEY

Site	Latitude	Sowing	Observed final leaf number	Observed leaf appearance rate (° Cd per leaf)
Aberdeen	57° 11'	1	12	107.0
		2	10	99.0
		3	9	88.5
Auchincruive	55° 28'	1	16	98.0
		2	11	123.5
		3	10	95.2
Great Kendale	53° 58'	1	13	103.8
		2	12	96.2
		3	11	89.4
Sutton Bonington	52° 48'	1	16	112.4
		2	13	100.5
		3	11	87.0
Brooms Barn	52° 15'	1	15	109.9
		2	14	111.1
		3	11	88.1
PBI	52° 11'	1	15	107.0
		2	12	104.2
		3	10	91.7
Rothamsted	51° 49'	1	15	97.1
		2	12	94.3
		3	11	84.8
Long Ashton	51° 27'	1	16	100.5
		2	13	102.6
		3	11	103.1
Seale Hayne	50° 32'	1	15	128.2
		2	12	105.3
		3	10	98.0

TABLE 2.

CALCULATED (C) AND OBSERVED (O) DATES OF DOUBLE RIDGES (DR) AND TERMINAL SPIKELET (TS)

Site	Sowing	DR		TS	
		O	C	O	C
Aberdeen	1	28/2	22/2	12/4	14/4
	2	5/4	17/3	3/5	24/4
	3	22/4	15/4	10/5	7/5
Auchincruive	1	25/2	25/2	11/4	5/4
	2	6/4	24/3	28/4	27/4
	3	18/4	2/4	2/5	27/4
Great Kendale	1	2/3	8/3	18/4	18/4
	2	3/4	8/4	1/5	3/5
	3	18/4	30/4	17/5	24/5
Sutton Bonington	1	31/1	28/3	14/4	27/4
	2	31/3	31/3	17/4	24/4
	3	14/4	14/4	29/4	1/5
Brooms Barn	1	6/3	5/3	17/4	18/4
	2	3/4	28/4	1/5	23/5
	3	17/4	19/4	2/5	8/5
PBI	1	12/1	9/2	13/4	5/4
	2	14/3	16/3	20/4	20/4
	3	13/4	7/4	5/5	27/4
Rothamsted	1	30/1	9/2	10/4	31/3
	2	23/3	15/3	23/4	16/4
	3	17/4	15/4	5/5	29/4
Long Ashton	1	12/1	31/1	27/3	15/3
	2	5/3	9/3	13/4	10/4
	3	10/4	11/4	26/4	29/4
Seale Hayne	1	9/1	14/2	17/3	4/4
	2	6/3	3/2	13/4	13/3
	3	8/4	3/3	23/4	8/4

TABLE 3.

MEAN DIFFERENCES IN DAYS (SIGN NEGLECTED) BETWEEN THE OBSERVED AND CALCULATED DATES OF DOUBLE RIDGES (DR) AND TERMINAL SPIKELET (TS)

Sowing	DR	TS
1	18	8
2	12	9
3	9	6